Art. XVII.—*Notes on Post Tertiary Strata in South-Western Victoria.*

By John Dennant, F.G.S.

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I.—*Dune Limestone*, Recent.

Amongst the prevailing tertiary strata in the counties of Follett and Normanby there are certain deposits of still later age, which, though limited in extent, are, from their mode of occurrence, of great geological interest. They may be arranged chronologically into two distinct sets of beds, the most recent of which will be first considered.

If the traveller leaves Portland to go to the pleasant little watering-place at Cape Bridgewater, he is struck by the sight of an outcrop of rock dipping at various angles amongst the consolidated sand dunes through which the road winds. The strata are very abundant along the coast from Portland to the border of the colony, and for many miles farther west in South Australia. They are met with also for a short distance inland, but chiefly in quarries, being usually hidden from view on the surface by a thin covering of drift sand. The only use of the rock is as a rough kind of building stone, where other materials are not available. Churches, schools, &c., constructed of it are generally pointed off with a finer kind of stone, and these have, for bush edifices, quite a passable appearance. Being of a very porous nature, the blocks of stone used need to be thick to avoid damp; but even then this defect renders it undesirable for dwelling-houses.

The strata are highly laminated, the weathered edges breaking off into leaves as thin as flags of roofing slate, with the laminations, of course, always parallel to the bedding planes. These, however, are seldom horizontal, the most characteristic feature of the beds being their constantly changing dip, not only in direction, but also in amount. The highest observed inclination was 30 degs., but between this and 0 deg. almost any angle may be found.

Locally the rock is called sandstone, from its coarse appearance, but it is essentially a carbonate of lime, the silica obtained from a sample analysed being as low as 4 per

cent. In composition it perfectly resembles the sand of the coast dunes, a coincidence which it is important to note in discussing the origin of the formation.

Between Portland and M'Donnell Bay there is a fringe of these dunes, or sand hummocks, as they are often called, extending from the sea margin to a distance of from one to three miles inland. Their altitude is considerable, many being 100 feet, and some even exceeding 200 feet, in height. They consist simply of sand, which, first washed on shore by the waves, has then been heaped up higher and higher by strong southerly winds. Within their land and sea boundaries flats and hollows are frequently left, and here pools and small lakes of fresh water are sometimes formed; or, again, the whole space is occupied by a series of smaller dunes, disposed in the most irregular manner. Usually there is no vegetation, and nothing meets the eye but glistening masses of white sand, making a landscape of the most weird and desolate character.

The bare dunes of the coast are succeeded for a few miles inland by others, which, in the course of time, have become covered with vegetation; but their rounded outlines are still preserved, giving to the region where they occur an undulating, billowy appearance, the contour of the land being exactly what would result from the gradual upheaval of successive rows of dunes, similar to those now forming on the seashore. As we go farther inland the country becomes less and less undulating, until, at a distance of 10 or 12 miles, the level plains of the interior are reached. Although sand is abundant here, there are no dunes, and they were either never formed, or have been since entirely removed. It is most likely that the coast action, which favoured the accumulation of sand into dunes, did not begin to operate till after the elevation of the plain country. Even in some localities where there are extensive sand hummocks on the sea margin no inland dunes exist; but we may easily account for their absence in such places by supposing the shore outline to have been different in former times. There are indeed indications of considerable alteration in this, particularly in the volcanic region around Portland, where the coast is both broken and precipitous, many bays and headlands having been formed by inroads of the ocean. It is further evident that these changes have taken place since the deposition of the earlier dunes, as their consolidated remains are plainly visible amongst the cliffs.

Such is the case at Nelson Bay, where a section of the strata is exposed more than 100 feet in thickness, the whole internal structure of the dunes being laid bare. The dip is quaquaversal, and the face of the cliffs presents precisely the appearance that might be expected from a perpendicular cut through a series of hardened sand dunes. At the top the actual rounded outlines of the original dunes are distinctly shown toward the landward side, while the seaward portions have been carried away by the action of the waves and spray. At Cape Grant, a little farther east, and on the western side of Cape Bridgewater, the coast features are exactly similar—viz., ridges rounded on one side, but abruptly terminated on the other by steep cliffs, the inclination of the beds also continually changing.

On the peninsula joining Cape Bridgewater to the mainland a still more instructive section of the strata may be observed. Just on the rising ground facing the Bay a landslip has occurred, by which a consolidated sand dune has been cleft from top to bottom, the two portions being now separated by a wide chasm. The rocks on both sides are very hard, and from weathering, their laminated structure is well illustrated, the edges standing out prominently in thin flags. Their ever-changing dip is, however, the most interesting feature, as, besides being typical of the formation generally, it permits us in this case to trace the former junction of the two masses, for although the dip is so various on either face, ranging from 30 degs. to 0 deg., yet at exactly opposite parts of each it is the same. The prevailing slope where the break has taken place is towards the severed portion—that is, seaward, and to the undermining action of the waves must, no doubt, be attributed the subsidence of such an immense mass of material. It is probable that, in the course of time, the whole of it will yet be removed, leaving then only the upper face as a cliff immediately overhanging the sea. With such an example before us, it is not difficult to account for the sharply-cut cliffs at Nelson Bay and other places on the coast. The fractured sand dune at Cape Bridgewater has been appropriately named "The Cloven Rock," and it is pointed out to visitors as one of the natural wonders of this favourite summer resort.

The dunes amongst which these bold cliffs occur have existed for some time, as their tops are now clothed with verdure; but if those more recent and still barren mounds on the sea-beach are examined, it becomes apparent that

their gradual consolidation is producing a similar rock. Thus, at Swan Lake, in the very heart of the drifting sand hummocks, the rock crops out where the overlying sand of a *partially* consolidated dune has been blown away by the wind, the exposed hardened portions showing the quaqua-versal dip that is so striking in the Nelson Bay cliffs. Indeed, on the very margin of this small lake, minor cliffs have been formed, which are miniature copies of those against which the foaming waves of the Southern Ocean dash themselves. Occasional outcrops of the rock may, in fact, be found in almost any part of the hummock region from Portland Bay to the boundary of the colony. At the Glenelg mouth it is seen in different stages of formation, from solid rock down to that which is so loose and crumbling as to give way at the slightest touch.

With the aid of a lens the component parts of the rock can be fairly well distinguished. Little white specks, which run pretty evenly through it, are simply small pieces of shells, usually thin and sharp; but the main mass consists of rounded fragments of corals, bryozoa, &c. It is true that whole shells are sometimes found among the recent hummocks, and their absence from the rock might at first sight seem strange; but it must be remembered that the sand is in continual motion, being drifted hither and thither by the force of the wind, and long before consolidation could take place they would be broken into unrecognisable fragments. At Bridgewater and other places where the sand is still unconsolidated, recent shells are found, not only in hollows, but also for a considerable distance up the dunes. It is not difficult, however, to understand how they came there, since shells are at the present day being deposited on the shifting sand dunes of the beach in precisely the same manner, washed up, no doubt, by the surf during storms. It is evident that these mounds of loose sand can never have been submerged after being once formed, or they would speedily have been levelled by the waves.

The same remark may, of course, be made with regard to the inland dunes, while they were yet in the unconsolidated state; and it is probable that a gradual elevation of the coast-line has continued during the formation of the entire series of dunes.

There are two minor deposits on the coast which may be mentioned here. At Narrawong, and also near the mouth of the Glenelg, on the landward side of the coast hummocks,

and at a lower elevation than these, a thin stratum of limestone occurs, full of shells, exactly like those on the adjacent beach. It is a kind of travertine, which while forming has enclosed the shells left on the low-lying ground. The localities where it has been observed are not now more than 30 feet above sea level. Though contemporaneous with the sand-dunes, it is an independent deposit.

In many places near the coast, where from local circumstances neither travertine nor sand-dunes have been formed, similar shells are found in the soil or in patches on the surface of the ground. They are chiefly interesting from the additional proof they afford of the upheaval of the land in quite recent times.

It is necessary to notice also that in one or two localities narrow ridges of the dune limestone jut out seaward for a short distance, but their presence in such a position may be accounted for, I think, by supposing minor alterations of the coast line to have taken place subsequent to the consolidation of the strata. Near the Glenelg mouth, two of these outcrops occur within a few miles of each other, only one of which I have had an opportunity of examining closely—viz., that nearest the river. In it the rocks commence on the beach, and extend about a hundred yards from the land, when they terminate abruptly. The ridge is not more than 20 or 30 feet high, and a dozen yards in width in any part; nor is it continuous, bare spaces being left here and there, where no signs of rock appear. The second outcrop, as seen from a distance, looks very similar, and both are probably the remains of low headlands, which the waves have almost succeeded in demolishing.

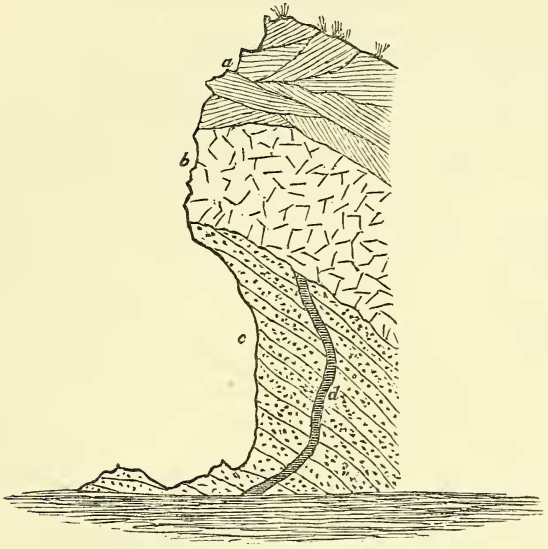
That the deposit is not deep-seated is plainly enough demonstrated, when the volcanic country surrounding Cape Bridgewater is examined, as its junction there with the underlying igneous rocks is conspicuously displayed on the face of every cliff. These rocks belong to a lava flow which issued from an extinct vent in the vicinity prior to the formation of the sand dunes. The two sets of beds meet a good way up the cliffs, but not at a uniform level, the surface of the basalt being far from horizontal, while the thickness of the limestone in any place depends, of course, upon the varying height of the original mounds of sand, of which it is a consolidated remnant. The Lawrence Rock, off Cape Grant, is an outlier of the same strata, now separated from the mainland by a channel deep enough for navigation

by small vessels, and just as on the cliffs of the adjoining cape, the lower portions consist of basalt, and the upper of limestone.

The mode in which the volcanic rocks of this neighbourhood occur is of special interest, as it enables us to note the relative age, not only of the dune limestone, but also of the underlying sedimentary strata. At the Whaler's Bluff, Portland, three separate formations are exposed in section—viz., the coralline (miocene) at the bottom, next the oyster beds, and finally the basalt at the top. Here the dune limestone is absent, but as the coast is traced round to the west, it soon appears, crowning the lava on the cliffs at Cape Grant. In no case are the igneous rocks covered by any other deposit, and it is, therefore, the most recent of all.

The extinct crater from which the fiery stream proceeded must have been situated somewhere near the sea margin, either on the land, or at a very short distance from it. Skirting Discovery Bay is a series of low cones, extending from Mount Vandyke on the north to Mount Richmond on the south. Now, Cape Bridgewater is itself a volcanic hill, and is, moreover, the most southerly extension of the same line of disturbance, its distance from the last-mentioned elevation being only six or seven miles. An examination of the cliffs at this promontory will prove, I believe, that here we have the source of most of the basalt underlying the dune limestone. The highest point of the cape is 460 feet above sea level, and is found at about a mile from its extremity, close to the cliffs overlooking Bridgewater Bay. By walking along at the base of these, on what is called the "flat rock," and looking upwards, we see the internal structure of what is evidently an old volcanic cone completely disclosed. The lowest portions, including the rock on which we stand, consist of stratified volcanic ash, of a greyish brown colour, with angular pieces of basalt, varying in size from minute grains up to fragments as large as a man's head, thickly scattered through it, the whole being cemented together so firmly as to form a tolerably hard stone. Above it is covered by a layer of ropy, scoriaceous lava, which has welled out of the old crater after the first discharge of lapilli and dust. In places, the ash deposit is almost horizontal, but towards one particular spot it shows a gradually increasing inclination up to a maximum of about 30 degs. Just here a vertical dyke of lava, not more than a foot thick, intrudes completely through it, and joins the once molten

mass at its top. Being very dense and compact, it has been able to resist the degrading action of the waves longer than the more friable material on each side, from which it now stands out like a projecting wall.



Sketch Section of Cliff at Cape Bridgewater.
a, Dune limestone; *b*, basalt; *c*, volcanic ash; *d*, lava dyke.

On the western side of the cape no ash is visible, the basalt reaching down to the water's edge. The same is the case at its southern extremity, and the centre of volcanic activity must thus have been somewhere on its eastern side.

It should be mentioned that at the top of all the cliffs there is the usual deposit of dune limestone, but only up to a height of about 250 feet, that portion of the promontory which still rises by a gradual slope some 200 feet higher, showing no trace of it, the basaltic rocks cropping out instead on the surface. The volcanic mound, therefore, of which Cape Bridgewater is a remnant, was probably formed near the shore, its summit first appearing above the surrounding waves, while the sheets of lava which issued from it were spread out on the sea bottom, their present elevated position being due, of course, to a subsequent steady upheaval of the southern coast; as the rocks slowly emerged

from the ocean, deposits of calcareous sand accumulated upon them, which, having consolidated, now remain as stratified beds overlying the basalt.

II.—*Bankivia Beds,* Pleistocene.

I have next to call attention to a remarkable fossil deposit on the banks of the Glenelg river, almost midway between Casterton and Dartmoor. Some shells from this neighbourhood were given to me about three years ago, and Professor Tate, to whom they were submitted, pronounced them to be recent and to be represented for the most part by species now inhabiting the adjoining seas. Subsequent collections included a very few of rather older appearance than the rest, reducing the percentage of living species slightly. It was a great surprise to find such fossils so far from the coast, and I took the first opportunity of visiting the locality and noting the position of the beds.

The shells occur in abundance on the very margin of the Glenelg, just at the junction of the Limestone Creek with it, and along the banks of the river as far up as the Old Pieracle station, where a selector now lives named Roscoe, from whom I have received much help in my search for fossils. The deposit appears to cease here, as no shells were found farther north, the bed of the river, as well as the banks for 40 or 50 feet up, being composed of drift full of quartz pebbles, mica, and nodules of ironstone (limonite). It extends, however, for some distance below Limestone Creek: how far it would be difficult to determine exactly, as the beds thin out gradually. The most notable spots for shells are situated between the places mentioned.

The nearest point of the coast is about 25 miles in a direct line from Limestone Creek, but the river meanders along for fully 120 miles before it discharges itself into the sea at Nelson.

About half a mile above the Limestone Creek junction, near a romantic spot known as the Devil's Den, the bank of the river is a mass of stone containing numerous oyster and other shells confusedly mixed together. Sometimes the carbonate of lime forms a cement by the partial dissolving of the shells themselves. It has made quite a hard stone; but the shells are principally on the surface, standing out clear, and not looking as if an integral part of the stone. A similar rock was mentioned in the first part of this paper as a recent formation at Narrawong, Nelson, &c., the only

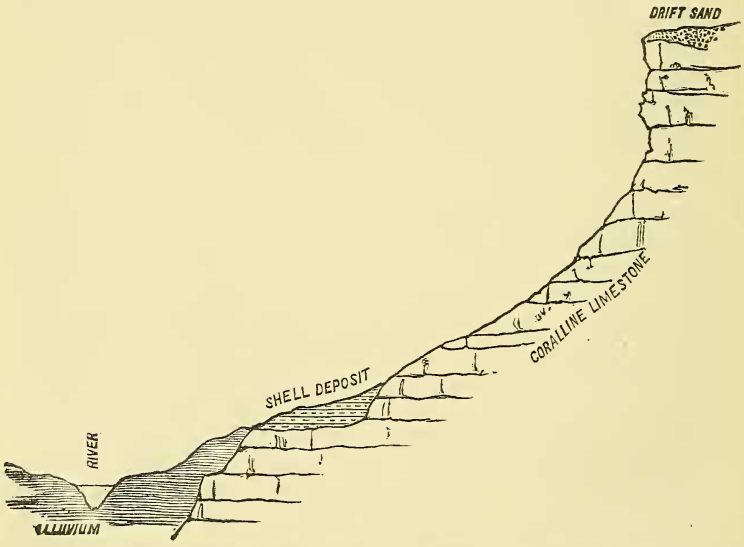
difference being that in it the enclosed shells are the most common ones of the present sea beach; while in the Glenelg deposit a few of them are not now found on the coast. The shells at the Devil's Den occasionally encrust blocks of an older-looking rock, which are scattered here and there on the river banks: their origin will be explained presently. At a height of about 30 feet from the summer level of the water, there is a mass of conglomerated material, composed of clay, limestone, sand, &c., full of marine shells. The bank on which it occurs is on the edge of an extensive flat, over which the river sometimes flows in winter.

On the left bank of the river, opposite Roscoe's, the margin of the stream is in places covered by immense numbers of shells, reminding one forcibly of sheltered coves on the sea shore. Bivalves are very plentiful, particularly *Pectunculus obliquus, Leda crassa, Chione roborata, &c.* The univalves are mostly small, but large ones, such as *Fasciolaria fusiformis, Voluta undulata,* &c., are sometimes found, though they are generally more or less injured by being washed about, either by the river waters, or by the waves of the sea, which deposited them on a former beach.

A little higher up the stream, on a hill or point of land cut through by a small creek, a very friable rock crops out, consisting almost entirely of shells, loosely adhering together. Most of them belong to a species still extremely common on the coast—viz., *Bankivia purpurascens.* So abundant are they in this crumbling rock, that at first sight it seems to be composed of nothing else. They are present in thousands, nearly all quite perfect, and retaining their colour as completely as if just washed up by the tide. It is from the prevalence of these shells that I have called the deposits "Bankivia beds." They are, however, by no means the only shells in the place, as by examining the rock and the *debris* around, a great variety of species can be found. This is the most interesting outcrop of the fossil-bearing strata anywhere on the river. Its position and the fresh appearance of the shells give clear evidence of its being an original deposit. The spot where it occurs lies about 60 feet above the river bed, and is the greatest elevation at which I could find shells. The river never perhaps rises so far above its present channel, and the majority of the shells in the low-lying ground cannot come from here, but are derived from less elevated portions of the same strata. Near the same

place, indeed, there are shell-beds at only half this height, and therefore quite within the reach of flood waters. The heights to which floods have risen are known to residents by marks on trees, &c., and some of these, which were shown to me, must be fully 40 feet above the bed of the stream.

The hill, and the other shell-banks in its vicinity, are on the margin of an irregular terrace, which continues all along the river in this part of its course, at a height of from 30 to 60 feet above its bed. In the terrace there are occasional mounds or banks, but it usually forms extensive flats. Through these the river winds in such a tortuous manner that, to go in a straight line from bank to bank of the gorge, which is sometimes nearly two miles in width, the stream might have to be crossed two or three times.



Sketch Section. Left Bank of Glenelg Gorge at Roscoe's.

It is noticeable that the river frequently hugs one bank for some distance, and then crosses over to the other, so that the flats succeed one another on opposite sides of it. The same thing was observed by Professor Tate as a feature of the Murray*. In some other respects the two river gorges resemble each other, allowing for difference of size.

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* *Transactions Royal Society of South Australia*, 1884.

The shell beds, both at Roscoe's and the Devil's Den, are always near the main banks of the river, and when found along the one, they are generally absent from the other. I have seen no shells towards the middle of the flats, but these are, for the most part, covered by alluvium and sandy drifts, which conceal the underlying strata. Every flood, however, leaves behind a fresh deposit of shells in the bed, and on the margin of the stream, washed out from the fossiliferous portions of the terrace by storm waters. I am told that when a landslip of the black alluvium takes place, the shells are exposed in great numbers. Beneath the superficial accumulations there are probably numerous beds of shells, not perhaps regularly stratified, but forming banks in various parts.

The terrace just described is not, however, the only one in this part of the river's course, as between it and the water's edge there is usually another and much narrower one. This lies about 20 feet below the upper terrace, and extends for 20 or 30 yards only on either side of the river. I could find but few shells in it, and these few were always near the surface, as if they had been simply washed there from the higher ground.

The spots referred to as so thickly strewn with shells lie at a lower level still, and are merely the sloping banks of the river channel itself. The shells deposited upon them can, of course, only be gathered when the water is low.

The main banks of the river are at a height of from 130 to 160 feet above its bed, and thus from 70 to 100 feet higher than the upper terrace, the ascent from which to the banks above is often steep, and sometimes even perpendicular. The terraces follow closely the windings of the river, but the topmost banks bound its general course only. The Glenelg flows for about two-thirds of its length through a very wide, as well as deep, valley, though the river itself is but a moderate one. The depth of the gorge is tolerably uniform, but its width varies considerably, being greatest in the neighbourhood of the fossil beds, where it is, as I have said, nearly two miles across. It is about half this width a few miles to the north, and narrows also, though more gradually, to the south of Limestone Creek.

With the summit of the Glenelg banks commence the wide plains forming the heath and scrub lands of Follett and South Normanby. Occasionally, there is a gentle rise of 20 or 30 feet before the tableland is reached, though, as a

rule, the edge of the gorge is quite as high as the country farther inland. The same general level is maintained right down to the coast, interrupted by no other depressions than those formed by the river itself and its few tributaries.

The total number of species gathered up to the present time from these beds is 141. Of this number 7 are too worn for perfect identification, and 13 belong to species which have not been met with before, either fossil or living. The known species therefore amount to 121, of which 98 are recent only, while 15 others, besides being recent, are fossil also in other formations. The remaining 8 species occur as fossil only, chiefly in the older tertiaries of Victoria, South Australia, &c.

The following table contains a list of the various species, and also their distribution*:—

Species found in Limestone Creek beds.	Living.							Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania	New South Wales.	West Australia.	North Australia.	New Zealand.	Abbreviations— O.T. = Older Tertiary. a = upper beds, Older Tertiary. b = lower beds, Older Tertiary.
Echinodermata—								
Goniocidaris ?	..	..	..	..	..	..	..	Spine only.
Brachiopoda—								
Waldheimia sp.	..	..	..	..	..	..	..	Too worn for identification.
Lamellibranchiata—								
Ostrea Angasi, *Sow.*	..	*	*	*	..	*	*	Pareora and Wanganui systems, N.Z
Gryphaea tarda, *Hutton* ..	..	..	..	..	..	..	..	O.T. S. Austr. (b), N.Z. (b).
Placunanomia Ione, *Gray* ..	..	*	..	*	..	..	*	O.T. S. Austr. (a), Muddy Creek (b).
Pecten asperrimus, *Lam.* ..	..	*	*	*	*	..	*	
——— bifrons, *Gray*	..	*	*					
Limea austrina, *Tate*	..	*						
Mytilus Menkeanus, *Phil.* ..	..	*	..	..	*			
——— hirsutus, *Lam.*	..	*	*	*	..	..	..	Living also in Japan
——— Magellanicus, *Lam.* ..	..	..	..	..	..	..	*	Living also in South America. Fossil in Pareora and Wanganui systems, N.Z

* I wish here to express my great obligation to Prof. Tate, F.G.S., F.L.S. for his kindness in determining for me the species of these shells. I am indebted to him also for much of the information given in the table.

Species found in Limestone Creek beds.	Living.							Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	
Lamellibranchiata—								
Nucula obliqua, *Lam.*	..	..	*	..	..	*	..	Living also in New Guinea.
Leda crassa, *Hinds*	*	*	*	*	..	..	..	Living also in Q'sld.
Barbatia radula, *H. Adams* ..	*	*	*					
Limopsis Belcheri, *Ad. & Reeve* ..	*	*	..	..	..	..	..	Living also at C. of Good Hope. Fossil in Pleistocene, S. Austr., O.T. do. (a), Muddy Crk. (a & b)
Pectunculus obliquus, *Reeve*	..	*	*	..	*			
——— planiusculus, *Tate m.s.* ..	..	..	..	..	..	..	..	New species.
——— flabellatus, *T. Woods*	*	*	*					
Cucullaea Corioensis, *M'Coy* ..	..	..	..	..	..	..	..	O.T., S. Austr. (b), Tasmania (a), Muddy Creek (b)
Trigonia acuticostata, *M'Coy* ..	*	..	..	..	..	..	..	O.T., S. Austr. (a), Muddy Creek (a).
Mytilicardia crassicostata, *Lam.* ..	*	*	..	..	*			
Cardita bimaculata, *Deshayes* ..	..	..	*					
——— Gunnii, *Deshayes* ..	..	..	*					
Lucina quadrisulcata, *D'Orb.* ..	..	*	*	*	..	..	*	O.T., S. Austr. (a), Pareora, Wanganui, and Oamaru systems, N.Z.
Chione gallinula, *Lam.*	..	*	*	*	*			
——— roborata, *Hanley* ..	..	*	*					
——— aphrodina, *Lam.* ..	*	*	*	..	*			
——— scalarina, *Lam.*	..	*	*	..	*			
——— undulosa *Lam.*	..	*	..	*	*	*		
——— sp.	..	..	..	..	..	..	..	? New species; much worn.
——— sp.	..	..	..	..	..	..	..	Too worn for identification.
Cytherea rutila, *Hanley* ..	*	*	*	*				
Venerupis exotica, *Lam.* ..	..	*	..	..	..	*		
Dosinia anus, *Phil.*	..	..	..	..	..	..	*	
Mesodesma erycinaea, *Lam.* ..	..	..	*	..	..	..	..	Living also at Singapore.
Anapa triquetra, *Hanley*	..	*	*					
Sunetta Alicae, *Adams & Angas* ..	..	*						
Zenatiopsis angustata, *Tate* ..	..	..	..	..	..	..	..	O.T., S. Aust., Table Cape, Muddy Crk. (a).
Mactra sp.	..	..	..	..	..	..	..	? New species.
——— sp.	..	..	..	..	..	..	..	? New species.
Hemimactra sp.	..	..	..	..	..	..	..	? New species.

Species found in Limestone Creek beds.	Living.							Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	
Lamellibranchiata—								
Donax cardioides, *Lam.*		*	..	..	..	*	..	Lives also in New Guinea.
Corbula tunicata, *Hinds*	..	..	..	*	..	*	..	Lives also in Phillipines.
Myodora ovata, *Reeve*		*	*	*				
Barnea australasiae, *Gray*		*	*	..	..	..	*	
Gasteropoda—								
Murex octogonus, *Quoy & G.*		*	*	*	..	..	*	Wanganui system, N.Z.
Urosalpinx Paivae, *Crosse & F.*		*	..	*	..	..	*	
Epidromus Bednalli, *Brazier*		*						
Triton gibbus, *Tate*	..	..	..	..	..	..	..	O.T., Muddy Crk. (b)
——— Quoyii, *Reeve*		*	*	*				
——— Bassii, *T. Woods* ..		*	..	*				
Purpura textiliosa, *Lam.* ..		*	*	*	..	..	*	Pareora system, N.Z.
Cantharus Clarkei, *T. Woods* ..		*	..	*				
Trophon Petterdi, *Crosse*			..	*				
——— Paivae, *Crosse* ..		*	*	*	..	..	*	
——— sp.		..	..	..	..	..	..	? New species.
Fusus ustulatus, *Reeve*			*					
——— australis, *Quoy*			*	..	..	..	..	Pareora and Wanganui systems, N.Z
——— sp.		..	..	..	..	..	..	? New species.
Cominella costata, *Quoy & G.* ..		*	*	*	..	..	*	Wanganui and Awamoa systems, N.Z.
——— sp.		..	..	..	..	..	..	? New species.
Eburna (Zemira) australis, *Sow.* ..		..	..	*	*			
Nassa monile, *Kiener*		*	*	*	..	..	..	Living also in Polynesia.
——— fasciata ? *Chem.* ..		*	..	*				
——— lirella, *Beck*		..	*					
——— sp.		..	..	..	..	..	..	(aff. Jacksoniana, *Kiener.*)
Fasciolaria fusiformis, *Valenc* ..		*	*	*				
Columbella Lincolnensis, *Reeve* ..		*	*	*	*	*		
——— infumata, *Crosse*			*					
——— Angasi, *Brazier*			*	*	*			
——— Yorkensis, *Crosse & F.* ..			*					
Terebra ustulata, *Deshayes*			..	*				
——— spectabilis, *Hinds*			..	*	*	..	..	.. Living also at New Guinea & Sumatra
——— strigillata, *Linn.*			..	..	..	..	*	.. Living also in Polynesia.
Euryta pulchella, *Adams & Angas* ..		*						
Voluta undulata, *Lam.*		*	*					

Species found in Limestone Creek beds.	Living.								Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.		
Gasteropoda—									
Voluta fulgetra, *Sow.*	*	*	*						
—— mamilla, *Gray*	..	..	*						
Mitra scalariformis, *T. Woods* ..	..	..	*						
—— maculosa, *Reeve*	..	..	..	..	..	*	..		Living also in Polynesia and Red Sea.
—— Rosettae, *Angas*	..	*							
—— glabra, *Swainson*	*	*	*	*	*				
Imbricaria conovula? *Q & G.* ..	..	..	..	..	..	..	..		Living in Polynesia.
Marginella turbinata, *Sow.* ..	*	*	*	*					
—— Allporti, *T. Woods* ..	..	..	*						
—— Johnstoni, *Petterd* ..	..	..	*						
—— Tasmanica, *T. Woods* ..	..	..	*						
—— volutiformis, *Reeve* ..	*	*	*						
—— Stanislas? *T. Woods* ..	..	..	*						
—— ovulum, ? *Sow.* ..	..	..	..	*	..	..	..		O.T., Muddy Crk. (a)
—— formicula, *Lam.* ..	*	..	..	*					
Ancillaria australis, *Sow.* ..	*	..	..	..	..	..	*		Pliocene, N.Z. O.T., Muddy Crk. (a & b)
—— marginata, *Lam.* ..	*	*	*	*					
Clathurella bicolor, *Angas* ..	..	*	*	*					
Pleurotoma violacea, *Hinds* ..	..	..	..	..	..	*	..		Also living in New Guinea and Japan.
—— sp	..	..	..	..	..	..	..		Not yet named. O.T. Muddy Creek (b).
—— sp	..	..	..	..	..	..	..		Undetermined.
Clavatula monile, *Valenc* ..	..	..	..	..	..	*	..		Living in Pacific Ocean.
Mangelia Jacksonensis, *Angas* ..	..	..	..	*					
Cassis fimbriata, *Quoy & G.* ..	*	*							
Semicassis semigranosa, *Lam.* ..	*	*	*	..	*				
Trivia australis, *Lam.*	*	*	*	*	*	..	*		
Cancellaria granosa, *Sow.* ..	*	*	*	*					
—— sp.	..	..	..	..	..	..	..		Not yet named. O.T. Muddy Creek.
Potamides dubium, *Sow.* ..	..	*							
Turitella sp.	..	..	..	..	..	..	..		New species.
—— sp.	..	..	..	..	..	..	..		? New species.
Natica aurantia, *Lam.*	..	..	..	..	..	*	..		Living in Indo-Pacific.
—— conica, *Lam.*	*	*	*	*	*				
—— semifilosa, *Tate m.s.* ..	..	..	..	..	..	..	..		New species.
Crepidula monoxyla, *Lesson* ..	..	..	..	..	..	..	*		Pareora and Wanganui systems, N.Z
Trochita maculata, *Quoy* ..	..	..	..	..	..	..	*		Pareora and Wanganui systems, N.Z
Amalthea conica, *Schum.* ..	..	*	*						

Species found in Limestone Creek beds.	Living.							Localities where Fossil, and Remarks.
	Victoria.	South Australia.	Tasmania.	New South Wales.	West Australia.	North Australia.	New Zealand.	
Gasteropoda—								
Philippia lutea, *Lam.*	..	..	..	*	..	..	*	
Astele granosa, *Tate m.s.* ..	..	..	..	..	..	..	..	New species.
Zizyphinus Meyeri, *Phil.* ..	*	*	*	*				
——— Legrandi, *T. Woods* ..	..	..	*					
Chlorostoma sp.	..	*						
Bankivia purpurascens, *Beck* ..	*	*	*	*	..	..	*	Living also at Cape of Good Hope.
Euchelus Tasmanicus, *T. Woods* ..	..	*	*					
Clanculus variegatus, *Adams* ..	*	*	*	..	*	..	..	Also living in Phillipines.
——— Aloysii, *T. Woods* ..	..	*	*					
Thalotia Allporti? *T. Woods* ..	..	*	*					
Diloma odontis, *Gray*	*	*	*					
Liotia australis, *Kiener*	*	*	*					
Risella melanostoma, *Gmelin* ..	*	*	*	..	*			
Phasianella ventricosa, *Q. & G.* ..	*	*	*	*	*			
Turbo circularis, *Reeve*	..	*	*					
——— squamiferus, *Koch*	..	*	*					
Fissurella concatenata, *Crosse* ..	*	*	*	*				
Emarginula candida, *A. Adams* ..	..	*	..	*	..	..	*	
Acmaea marmorata, *T. Woods* ..	*	..	*	*				
Cylichna arachis, *Quoy* ..	*	..	*	*	*			
Scaphopoda—								
Entalis Mantelli, *Zittel* ..	..	..	..	..	..	..	..	O.T., N.Z. (b); S. Austr. (b); Muddy Creek (a & b)
——— annulatum, *Tate* ..	..	..	..	..	..	..	..	O.T., S. Austr. (b); Muddy Crk. (a & b)
Pulmonata—								
Helix coriaria, *Pfr.*	..	..	..	*				
—— sp.	..	*	..	..	..	..	..	(aff. Strangei).
Succinea australis, *Quoy & G.* ..	*	*	*					
Ampullarina ? sp.	..	..	..	..	..	..	..	Undetermined.
Pisces—								
Lamna sp.	..	..	..	..	..	..	..	Tooth.
Oxyrrhina (or Lamna) sp. ..	..	..	..	..	..	..	..	Tooth.

Reference has been made to the abundance of oyster shells amongst the Bankivia deposits, while no oysters are now found on our coasts, and the occurrence of these, as well as of the extinct shells mentioned, renders it desirable

to speak briefly of the more ancient strata, through which the Glenelg has carved out the southern part of its course—viz., the coralline limestone. The thickness of this is unknown, but that it is very great is certain, from the fact of there being no outcrop of a different rock for many miles in any direction. It underlies the bed of the river from its mouth almost as far as Casterton, where mesozoic and silurian rocks appear. Its fossils are numerous, and fairly well known; from their evidence the whole formation is considered to be of miocene age. At the Devil's Den is a massive cliff, 130 feet high, composed of this rock, and covered by a band of oyster shells, as is usual with the strata generally. Near it, similar though smaller cliffs exist towards the summit of the banks, while farther down the river, the limestone is continuous to the water's edge. At Ascot Heath, about ten miles south from Limestone Creek, the oyster beds at the top of the bank are as much as 8 or 10 feet thick, the coralline rock with its characteristic fossils lying immediately underneath. The oysters found on the Glenelg terraces are of the same species as those in the cliffs above; but it does not necessarily follow that they are derived from this source, their great abundance in the Bankivia beds being against such a theory, and we can only conclude that they were common to both formations. The small variety of fossils in the Ostrea limestone renders the determination of its age difficult, but it is undoubtedly much less ancient than the coralline strata, as amongst the few fossils which have been obtained from it, several are identical with living forms, while, as is well known, a large proportion of those in the coralline belong to extinct species.

Again, *Entalis annulatum*, *Cucullaea Corioensis*, &c. are frequent shells in the coralline formation, and the possibility of their derivation from it must be admitted. There are, however, certain considerations which induce me to take an opposite view, and to regard *them* also as part of the original deposit. Five of the eight extinct shells are very rare, being represented in my collection by solitary examples only, while specimens of most other species are tolerably numerous. With the exception of *Gryphaea tarda*, they are all found in some part of the Muddy Creek series, which is usually considered as equivalent to the coralline. There are altogether twelve species common to the Muddy Creek and Bankivia beds, of which five are recent as well as fossil, and as these five old tertiary

species have survived right down to the present day, we may easily suppose that the eight forms which have now become extinct were nevertheless living when the Limestone Creek beds were deposited.

The beds are, as yet, but partially examined, the only collection of shells made being, I believe, my own, and at each visit to the locality I have always succeeded in finding new species.

The actual proportion of living to extinct species is not, however, likely to be materially altered by further explorations. This amounts, so far, to about 95 per cent., and the deposit may therefore be fairly considered as of pleistocene age.

The height of the shell beds at Roscoe's cannot be given exactly, no levels having ever been taken in this part of the country; but approximate aneroid measurements show that they are from 75 to 100 feet above sea level. The bed of the river here is probably not more than 40 feet above sea level, though its waters have so far to travel before reaching the ocean. The tide comes up the stream for about eighty miles, and for this distance there is scarcely any fall. For some miles from its mouth the bed is actually below sea level, as proved by soundings.

Between the river banks and the sea there is no low ground whatever, the fall at the coast being very sudden. The only possible theory, therefore, which can account for this modern deposit is, that Roscoe's and the Limestone Creek flats were in reality an old estuary of the Glenelg, before the land to the south had risen. This estuary was bounded on the east and west by high land, and sometimes by cliffs of coralline limestone, ranging from 70 to 100 feet above the level of the river at that time. Opposite Gilmore's (between Roscoe's and Limestone Creek), a projecting tongue of land extends for nearly a mile into the very centre of the flat, which it divides into two parts for this distance. At the top, it is only a few yards in width, and slopes rapidly down to the terrace on either side, while it maintains throughout the same general elevation as the table land from which it springs, jutting out like a bold headland at sea. Its sharp outline in the midst of this extensive and almost level flat is very striking, and much more suggestive of coast action than of that of a river current. On its sides, the coralline limestone crops out, and the whole ridge consists, no doubt, of harder portions of this rock, which the

waters were unable to wear away. These broad flats have thus been formed, partly by the river, and partly by the sea itself, which had access to the estuary, and the shells which were so plentifully strewn on sheltered places under the river cliffs have been since cemented together, more or less completely, sometimes forming a hard rock, and at others a very friable one. In some cases, blocks of the ancient limestone, thrown down from the cliffs, have been encrusted with the shells, which adhere firmly to them. It is not easy always to distinguish between the two rocks, unless a close examination is made, when the older one is seen to contain its characteristic fossils, corals, bryozoa, &c., while in the newer these are, of course, wholly wanting.

The Bankivia beds were most probably laid down during the upheaval, which has raised the whole of the south coast of Victoria, a period of rest occurring while the upper terrace was being formed. Although, as said just now, the great width of the flats here must be in a great measure due to sea action, they were, no doubt, first shaped out by the river itself, as flats of tolerable size are found almost to its source, and amongst very varying strata, a wide excavation having been made in the upper part of its course through slate, sandstone, and even granite. It is most significant that the flats diminish in extent to the south of Limestone Creek, and soon cease altogether, the gorge narrowing so much that for the last 70 or 80 miles of the river's course the opposite banks are seldom more than 300 or 400 yards apart, while the successive terraces no longer appear, the cliffs rising directly from the water's edge. In no part of the river are the banks so widely separated as in the neighbourhood of Limestone Creek. Here, I believe, the mouth of the Glenelg remained for a long period, enabling a vast accumulation of littoral shells to take place. As the land rose, the estuarine deposit was gradually removed farther and farther from the coast, while the river has, in the course of time, cut a winding channel through the flats, and through the ancient limestone farther south, as this gradually emerged from the bed of the ocean.
